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THE FREEZING TEMPERATURES OF SOME FRUITS, VEGETABLES, AND CUT FLOWERS

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INTRODUCTION

There is an ever-increasing demand from persons interested in the growing, shipping, and handling of produce for exact data on the freezing points, or the temperatures at which various products freeze.

The extent of damage due to the freezing of produce in transit naturally varies from year to year, but it is usually very heavy, aggregating frequently several hundreds of thousands of dollars during a year. This in general applies not only to such products as apples and potatoes, most of which are grown in the North and harvested and shipped in the late fall and winter, but to products which are grown in the South and Southwest during the winter and shipped to the northern markets. This latter group includes citrus fruits, strawberries, tomatoes, lettuce, string beans, cabbage, cauliflower, eggplant, etc. Cars of these food products often leave the shipping point under refrigeration and in 24 to 36 hours may pass into a zone of freezing temperatures. As they approach the more northern markets they may be exposed to temperatures ranging several degrees below their freezing point. Under certain conditions when harvested in warm weather some of these products are precooled—that is, rapidly cooled to a refrigerating temperature, either immediately before or directly after they are placed in the car for shipment, in order to delay maturity and consequent deterioration. Where precooling is practiced, it is, of course, essential to know the temperatures to which the product can be lowered with absolute safety.

It is of great importance to the commercial cold-storage man to know the exact freezing points of fruits and vegetables that he handles. In most cases fruits and vegetables other than dried or prepared products when placed in cold storage are alive, and the problem is to keep them alive and healthy throughout their storage period. Since various fruits and vegetables freeze at different temperatures, there is more or less doubt in the minds of those interested as to the proper and safe temperatures at which to hold these various products in storage. One of the problems in the storage of many of these products is to hold them at a temperature low enough to slow down the living processes in order to prolong their storage life

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and yet not allow them to be damaged by actual freezing. With many products this storage temperature is only 1 or 2 degrees above the actual freezing point. Of course some products, such as berries, may be purposely kept in a frozen condition below freezing temperature, but this subject comes under the head of freezing storage and will not be discussed here. It is therefore essential in commercial work of this kind that accurate data be at hand on the temperatures to which these products can be exposed without injuring their keeping qualities or market value.

It should be borne in mind, however, that freezing or freezing injury does not always occur when fruit or vegetable products are exposed to temperatures at or below their true freezing points. This is shown in the studies on potatoes reported in a previous publication,[1] where tubers were cooled as much as 10° F. below their freezing points without actually having become frozen and again warmed up without apparent injury. The commonly known fact that some kinds of products may be actually frozen and then thawed out under certain conditions with no apparent injurious effects constitutes further evidence on this point. On the other hand, certain commodities such as tomatoes, bananas, and cucumbers are injured if stored at temperatures many degrees above their actual freezing points. This is usually termed chilling injury. It is evident, therefore, that temperatures just above the freezing point can not be regarded as safe for all types or varieties of fruits and vegetables. It is also noticeable that there are some variations in the freezing points of fruits or vegetables of the same variety and from the same lot, as is shown in the tables that follow. Furthermore, it is quite probable that different individuals of the same variety and strain when grown under different conditions will have somewhat different average freezing points. Attention is therefore called to the fact that the freezing points given in the following tables should be considered as danger points; that is, at or near these temperatures, either above or below them, there is a possibility that the product will be in danger of injury by freezing if exposed for a sufficient length of time. These are temperatures at which it is unsafe to hold produce which is to be used for food if it is desired to maintain it for any length of time in a living condition.

The determinations of the freezing points of a number of fruits and vegetables have been made by the Bureau of Plant Industry in connection with its cold-storage investigations. By freezing point is meant the temperature at which ice crystals begin to form within the product, either fruit or vegetable.

Some 10,000 of these determinations have already been made on many varieties of commercially grown fruits and vegetables, and work is being continued. It has been found in some cases that the freezing points of some varieties are liable to slight variations from year to year, even though the same strain grown in the same locality is used. These variations, however, are probably of more importance in the study of the exact causes and results of freezing injury than from the point of view of the commercial cold-storage and produce man, for the variation of a fraction of a degree hardly warrants any change in the treatment of the product. It therefore seems advisable to publish the results of these investigations from

[1] WRIGHT, R. C., AND TAYLOR, GEORGE F. FREEZING INJURY TO POTATOES WHEN UNDERCOOLED. U. S. Dept. Agr. Bul. 916, 15 p., 1 fig., 1 pl., 1921. Literature cited, p. 15.

time to time as obtained, because of the need for such information and because there is no comprehensive publication on the subject.

The method of determining freezing points has been described in former papers,[2] and a repetition of this description is not required here.

FREEZING POINTS OF FRUITS

Where several varieties of one kind of fruit were investigated the results are given separately to allow comparisons to be made.

Apples.—Freezing-point determinations were made for a number of authentic varieties of summer or early apples and of fall and winter varieties, most of which were grown on the Arlington Experiment Farm, Rosslyn, Va. The tabulated results given by varieties are shown in Table 1. These results show considerable varietal differences among both summer and winter apples. The average of all summer varieties is practically the same as that of winter varieties, the former being 28.44° while the latter is 28.51° F. These results show very little difference between the freezing points of eastern-grown and western-grown fruit.

Cherries.—Freezing-point determinations were made for seven varieties of cherries grown on the Arlington Experiment Farm. The average of all varieties was 27.81° F. (Table 1.)

Grapes.—Results were obtained from the freezing of seven American and two European varieties of grapes. The average freezing point of the American varieties was 28.16° F., and that of the European varieties was 24.60°. (Table 1.)

Oranges.—The average freezing point of the six varieties of oranges studied was 28.03° F. (Table 1.)

Peaches.—Freezing-point determinations were made for 11 varieties of peaches grown near Leesburg, Va., in the Loudoun orchard of the American Fruit Growers (Inc.). Peaches in the hard-ripe stage were utilized for these tests. The average freezing point of all varieties when hard ripe was found to be 29.41° F. (Table 1.)

Plums.—Freezing points were obtained for four varieties of plums that were grown in California and purchased on the market and for one variety (Red June) grown at the Arlington Experiment Farm. The variety with the lowest freezing point is Tragedy, with a freezing temperature of 27.21° F. The average freezing point of all varieties is 28.53°. (Table 1.)

Strawberries.—Freezing-point determinations were obtained for 22 authentic varieties of strawberries grown at the Maryland Agricultural Experiment Station. The greatest difference was found between the Lupton, which froze at 28.84°, and the Hustler, at 30.48° F. The average for all varieties was 29.93°. (Table 1.)

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[2] TAYLOR, GEORGE F. SOME IMPROVEMENTS ON THE NEEDLE TYPE THERMOCOUPLE FOR LOW-TEMPERATURE WORK. Jour. Ind. and Eng. Chem., v. 12, p. 797–798, 1 fig. 1920.

WRIGHT, R. C., and HARVEY, R. B. THE FREEZING POINT OF POTATOES AS DETERMINED BY THE THERMOELECTRIC METHOD. U. S. Dept. Agr. Bul. 895, 7 p., 1 fig. 1921. Bibliographical footnotes.

WRIGHT, R. C., and TAYLOR, GEORGE F. FREEZING INJURY TO POTATOES WHEN UNDERCOOLED. U. S. Dept. Agr. Bul. 916, 15 p., 1 fig., 1 pl. 1921. Literature cited, p. 15.

TABLE 1.—*Average and extreme freezing points of fruits*

Fruit and varieties	Temperatures (° F.)		
	Average	Extremes	
		Minimum	Maximum
Apples, summer varieties:			
Yellow Transparent	27.72	27.29	28.16
Red Astrachan	28.58	28.25	28.70
Early Ripe	29.18	28.82	29.47
Red June	29.59	29.29	29.71
Sweitzer	27.38	27.32	27.41
Shoemaker	28.46	27.93	28.03
Benoni	28.83	28.49	29.00
Early Joe	27.81	27.60	28.49
Martha (crab)	26.70	26.62	26.76
Average (not including the crab apple)	28.44	28.12	28.62
Apples, fall and winter varieties, eastern grown:			
Baldwin	29.04	28.84	29.43
Ben Davis	28.61	28.21	28.96
Delicious	28.48	28.16	29.10
Grimes	28.97	28.82	29.05
Jonathan	28.22	27.79	28.69
Paragon	28.50	28.45	28.55
Rambo	28.55	28.34	28.90
Stayman Winesap	28.51	28.02	28.91
Winesap	28.23	27.93	28.72
Yellow Newtown	28.00	27.80	28.20
York Imperial	28.34	28.10	28.50
Average	28.49	28.22	28.82
Apples, fall and winter varieties, western grown:			
Delicious	28.36	27.98	28.86
Gano	28.55	28.26	29.05
Grimes	28.60	28.26	29.05
Jonathan	28.35	28.02	28.72
Rome Beauty	28.92	28.72	29.38
Esopus (Spitzenberg)	28.69	28.26	29.05
Winesap	28.24	27.93	28.35
Average	28.53	28.20	28.92
Cherries:			
Early Richmond	27.94	27.60	28.35
Montmorency	28.10	27.79	28.58
St. Medard	28.09	27.60	28.58
Royal Nouville	28.16	27.95	28.50
Gloire de France	27.65	27.37	28.21
Mecker	26.88	26.76	27.69
Bigarreau (unknown variety)	27.83	27.83	27.83
Average	27.81	27.56	28.25
Grapes:			
American varieties—			
New Concord	28.39	27.93	28.68
Ambrosia	28.21	27.83	28.63
Dracut Amber	27.88	27.77	28.10
Moores Early	28.28	28.15	28.62
Captivator	27.86	27.14	28.05
Campbell (black)	27.96	27.77	28.00
Mericadel	28.54	28.40	28.54
Average	28.16	27.85	28.37
European varieties—			
Malaga	24.60	24.60	24.80
Emperor	24.60	24.10	24.76
Average	24.60	24.35	24.78
Oranges:			
Temple	28.64	28.34	28.82
Pineapple	27.72	27.60	27.83
Florida Seedling	28.20	28.10	28.43
Washington Navel	28.42	28.30	28.68

Fruit and varieties	Temperatures (° F.)		
	Average	Extremes	
		Minimum	Maximum
Oranges—Continued.			
Valencia (California)	27.01	26.90	27.60
Satsuma (Owari variety)	28.18	27.93	28.68
Average	28.03	27.86	28.34
Peaches (hard ripe):			
Belle	29.82	29.50	30.28
Elberta	29.72	29.43	30.00
Stevens	28.65	28.25	28.90
Edgemont	29.40	29.30	29.50
Williams	29.56	29.10	30.00
Bilyeu	28.90	28.35	28.96
Smock	29.28	29.05	29.57
Salwey	29.57	29.10	29.80
Hiley	30.02	29.90	30.24
Carman	29.57	29.30	29.95
Champion	29.06	28.73	29.95
Average	29.41	29.09	29.74
Plums:			
Burbank	29.26	29.05	29.80
Wickson	29.53	29.19	29.75
Tragedy	27.21	26.76	27.41
Red June	28.13	27.79	28.44
Average	28.53	28.20	28.85
Strawberries:			
American	29.70	29.66	29.75
Big Late	30.03	29.25	30.05
Big Joe	29.98	29.78	30.19
Brandywine	29.96	29.85	30.36
Chesapeake	30.29	29.94	30.32
Dunlap	29.82	29.24	29.99
Excelsior	29.94	29.28	30.04
Early Ozark	29.82	29.66	30.13
Early Jersey Giant	29.82	29.43	30.22
Gandy	29.24	28.85	29.55
Glen Mary	30.08	29.53	30.16
Howard 17 (Premier)	30.23	29.58	30.38
Hustler	30.48	30.41	30.60
Klondike	29.59	29.28	29.90
Kellog (Kellog's Pride)	30.13	29.78	30.48
Late Jersey Giant	30.25	30.13	30.26
Lupton	28.84	28.82	29.10
Rewastico	30.05	30.03	30.13
Stevens	30.18	29.37	30.42
Sample	30.38	29.63	30.48
Superb	30.46	29.85	30.81
Twilley	29.22	28.96	29.53
Average	29.93	29.56	30.13
Blackberries:			
Jumbo	29.09	28.71	29.30
Eldorado	29.21	28.76	29.54
Crystal White	28.40	28.12	28.63
Logan (Loganberry)	29.51	29.32	29.75
Raspberries:			
Ranere (St. Regis, red)	30.41	30.12	30.50
Columbia (black)	28.76	28.24	28.79
Cranberries:			
Searl	28.20	27.93	28.44
Gebhart Beauty	26.30	26.00	26.60
Mammoth	26.70	26.40	26.90
Metallic	25.60	24.80	25.80
Chipman	26.89	26.01	27.36
Perry Red	27.93	26.62	28.05
Early Black	28.10	27.64	28.71
McFarlin	29.02	28.38	29.45
Shaw's Success	25.03	24.62	25.74
Howes	28.24	27.50	28.43
Pride	27.05	26.57	27.73
Wales Henry	28.70	27.92	28.00

TABLE 1.—*Average and extreme freezing points of fruits*—Continued

SUMMARY OF AVERAGES

Fruit and varieties	Temperatures (° F.)			Fruit and varieties	Temperatures (° F.)		
	Average	Extremes			Average	Extremes	
		Minimum	Maximum			Minimum	Maximum
Apples:				Grapefruit	28.36	28.00	28.50
Summer varieties	28.44	28.12	28.62	Lemons	28.14	27.89	28.47
Fall and winter	28.51	28.21	28.87	Oranges	28.03	27.86	28.34
Bananas (Jamaica):				Peaches (hard ripe)	29.41	29.09	29.74
Green—Peel	29.84	29.76	29.92	Pears (Bartlett):			
Green—Pulp	30.22	30.10	30.58	Hard ripe	28.46	28.06	28.70
Ripe—Peel	29.36	29.15	29.53	Soft ripe	27.83	27.20	28.00
Ripe—Pulp	26.00	25.45	26.50	Pears (unknown Japanese variety)	29.39	29.34	29.53
Blackberries:				Japanese persimmons (Tanenashi)	28.33	28.07	28.63
Black varieties	29.15	28.73	29.42	Plums	28.53	28.20	28.85
White varieties	28.40	28.12	28.63	Raspberries:			
Logan (Loganberry)	29.51	29.32	29.75	Red varieties	30.41	30.12	30.50
Cherries	27.81	27.56	28.25	Black varieties	28.76	28.24	28.79
Cranberries	27.16	26.28	26.93	Strawberries	29.93	29.56	30.13
Currants	30.21	30.18	30.25	Chestnuts (Italian)	23.80	23.00	24.20
Gooseberries	28.91	28.70	29.18	Walnuts (Persian or so-called English)	20.00	19.80	22.10
Grapes:							
American	28.16	27.85	28.37				
European	24.60	24.35	24.78				

Blackberries, raspberries, and cranberries.—Three varieties of blackberries were frozen, viz, Jumbo, Eldorado, and Crystal White. The two black varieties froze at 29.09° and 29.21° F., respectively, while the white variety froze at 28.40°. Logan blackberries (eastern grown), froze at 29.51°. One variety each of red and black raspberries was frozen. The Ranere (St. Regis) froze at 30.41°, while the Columbia froze at 28.76°. Four varieties of cranberries grown in Wisconsin and eight varieties grown in Massachusetts were frozen. Considerable differences were found in the freezing points of some of these varieties. While the McFarlin variety froze at 29.02°, Shaw's Success froze at 25.03°. The results for Gebhart Beauty and Mammoth are intermediate, being 26.30° and 26.70°, respectively.

Miscellaneous fruits.—A number of other fruits and berries were investigated, but only one variety was available in each case. The results are therefore not given separately, but are included in the summary of Table 1 covering the average freezing points of all the fruits studied. Two varieties of nuts were frozen, viz, Italian chestnuts, which froze at 23.80° and Persian or so-called English walnuts, which froze at 20.00° F.

FREEZING POINTS OF VEGETABLES

While several different kinds of vegetables have been used in the freezing-point determinations, those on which the most extensive variety studies have been centered are potatoes, sweet potatoes, and tomatoes.

Potatoes.—Freezing-point determinations were made on 18 different authentic varieties of potatoes. Bulletins 895 and 916 of the United States Department of Agriculture give the results of this study in detail, so they will not be discussed here. The average freezing points of all varieties was 28.92° F. (Table 2.)

TABLE 2.—*Average and extreme freezing points of potatoes, sweet potatoes, tomatoes, and other vegetables*

Kind and variety	Temperatures (° F.)		
	Average	Extremes	
		Minimum	Maximum
Potatoes:			
Triumph	29.20	29.00	29.33
Early Prospect	28.80	28.72	29.30
Irish Cobbler	29.67	29.60	29.72
First Early	29.00	28.88	29.00
First Early Standard	28.97	28.74	29.12
Ehnola	29.17	29.01	29.30
Spaulding No. 4	29.33	29.21	29.32
Green Mountain	28.50	28.38	28.55
Gold Coin	28.63	28.40	28.70
Rural New Yorker	28.70	28.46	28.75
Russet Rural	28.32	28.30	28.48
U. S. Seedling No. 38774	28.77	28.65	28.83
Up-to-date	29.10	29.10	29.10
Producer	28.70	28.73	28.79
Oregon White Rose	28.71	28.60	28.80
British Queen	29.27	29.22	29.30
Garnet Chile	28.16	28.00	28.28
American Giant	29.64	29.48	29.68
Average	28.92	28.80	29.02
Sweet potatoes:			
Big Stem	28.05	27.48	28.72
Dooley	28.46	27.93	28.91
Early Carolina	28.59	28.40	28.96
Georgia	28.05	27.79	28.58
Gold Skin	28.47	28.21	28.63
Improved Big Stem	28.76	28.26	29.00
Miles	28.34	28.16	28.54
Nancy Hall	28.10	27.54	28.35
Mullihan	27.64	27.46	27.93
Pierson	28.68	28.02	28.72
Porto Rico	28.34	27.87	28.68
Pumpkin	28.98	28.68	29.09
Red Brazil	28.40	28.30	28.63
Red Bermuda	28.17	27.98	28.63
Red Jersey	28.52	28.30	28.77
Southern Queen	28.56	28.25	28.82
Triumph	28.43	28.26	28.72
Yellow Belmont	28.57	28.49	28.82
Yellow Jersey	28.97	28.26	29.05
Yellow Strasburg	28.72	28.30	29.00
Average	28.44	28.10	28.72
Tomatoes (ripe):			
Bonny Best	30.60	30.48	30.68
Olney Special	30.59	30.34	30.67
Earliana	30.52	30.43	30.77
John Baer	30.57	30.24	30.90
Landreth	30.45	30.34	30.72
Early Michigan	30.67	30.19	30.85
Marvel	30.03	29.90	30.38
Bloomdale	29.99	29.90	30.53
Red Rock	30.55	30.48	30.62
Trucker's Favorite	30.06		
New Glory	29.78	29.63	30.38
Tomatoes (ripe)—Contd.			
Stone	30.31	30.10	30.58
Greater Baltimore	30.62	30.20	30.81
Columbia	30.31	30.29	30.77
Delaware Beauty	30.02	29.95	30.33
Livingston's Globe	30.58	30.32	30.88
Livingston's Acme	30.46	30.41	30.74
Greenhouse varieties—			
Carter's Sunrise	30.58	30.06	30.85
Stirling Castle	30.54	30.41	30.60
Average	30.38	30.20	30.67
Tomatoes (green):			
Bonny Best	30.57	30.38	30.83
Earliana	30.24	29.77	30.58
John Baer	30.53	30.48	30.58
Early Michigan	30.70	30.53	30.77
Red Rock	30.58	30.34	30.67
Stone	30.15	30.10	30.38
Greenhouse varieties—			
Carter's Sunrise	30.29	30.20	30.59
Stirling Castle	30.11	29.90	30.15
Average	30.40	30.21	30.57
Sweet corn:			
Crosby	29.07	28.82	29.43
Country Gentleman	29.11	28.63	29.43
Howling Mob	28.00	27.89	28.16
Golden Bantam	29.61	29.25	29.85
Average	28.95	28.65	29.22
Onions:			
Yellow Danvers	30.10	29.61	30.17
White Globe	30.20	29.75	30.41
Texas Bermuda	29.96	29.71	30.13
Average	30.09	29.69	30.24
Lettuce:			
May Queen	30.49	30.38	30.60
Way Ahead	31.54	31.25	31.77
Prize Head	31.57	31.45	31.77
Average	31.20	31.03	31.38
Carrots:			
Danvers	29.61	29.43	29.66
Chantenay	29.53	29.42	29.70
Average	29.57	29.42	29.68
Peas:			
Early Alaska	28.93	28.26	29.19
Horsford's Market Garden	30.93	30.73	30.99
Laxtonian	30.23	30.03	30.56
Average	30.03	29.67	30.25

SUMMARY OF AVERAGES

Beans (snap)	29.74	29.65	30.06	Lettuce	31.20	31.03	31.38
Cabbage (Early Jersey Wakefield)	31.18	31.06	31.34	Onions (dry)	30.09	29.69	30.24
Carrots	29.57	29.42	29.68	Onion sets (Yellow Globe)	29.50	29.00	29.90
Cauliflower	30.08	29.95	30.15	Peas (green)	30.03	29.67	30.25
Celery	29.73	29.70	30.00	Potatoes	28.92	28.80	29.02
Corn, sweet	28.95	28.65	29.22	Potatoes, sweet	28.44	28.10	28.72
Eggplant	30.41	30.17	30.69	Tomatoes (ripe)	30.38	30.20	30.67
Kohl-rabi	30.02	29.74	30.22	Turnips	30.23	30.16	30.48

Sweet potatoes.—The results of freezing 20 more or less common varieties of sweet potatoes are presented in Table 2. The varieties with the lowest freezing points are Big Stem and Georgia, both of which froze at 28.05° F. The highest freezing points were found

with Pumpkin and Yellow Jersey varieties, which froze at 28.98° and 28.97°, respectively. The average of all varieties was 28.44°.

Tomatoes.—The freezing temperatures of 19 commercially grown varieties of tomatoes were determined and are presented in Table 2. These tomatoes were all grown under the same conditions at the Arlington Experiment Farm. Determinations were made on both ripe and practically full-grown green specimens, such as are usually picked for shipment from the Southern States to the northern markets. With the ripe tomatoes the lowest freezing point (29.78° F.) was found in connection with the New Glory variety. The Early Michigan variety froze at 30.67°, which represents the highest freezing point of all the varieties studied. There was no appreciable difference in the average freezing points of ripe and green tomatoes, the averages being 30.38° and 30.40°, respectively.

Sweet corn.—The freezing point of sweet corn varied considerably with the age of the product. There was also considerable variation between varieties. Four varieties were studied. (See Table 2.)

Miscellaneous vegetables.—The freezing points of three varieties of onions, three varieties of lettuce, two varieties of carrots, and three varieties of peas, and of at least one variety each of beans, cabbage, cauliflower, celery, eggplant, kohl-rabi, onions, and turnips are also presented in the body or in the summary of Table 2.

FREEZING POINTS OF CUT FLOWERS

Requests have been received for information on the freezing points of such cut flowers as are commonly held in cold storage or shipped in quantities. Determinations were made for peonies, roses, and Easter lilies, and these are presented in Table 3. Results are shown for both petals and leaves. With peonies and roses the petals freeze at temperatures higher than do the leaves. Rose petals froze at 30.04° F., while peony petals did not freeze until a temperature of 29.05° was reached. In the case of Easter lilies the leaves froze before the petals, the latter not succumbing until the temperature reached 27.50°.

TABLE 3.—*Average freezing points of the petals and leaves of cut flowers*

Scope of inquiry	Peony		Rose		Easter lily	
	Petals	Leaves	Petals	Leaves	Petals	Leaves
Number of determinations	12	8	6	6		
Freezing point ° F.	29.05	28.39	30.04	28.27	27.50	29.20

RECAPITULATION

Freezing or freezing injury does not always occur when fruit or vegetable products are exposed to temperatures at or below their actual freezing points. Under certain conditions many of these products can be undercooled; that is, cooled to a point below the true freezing temperature of each and again warmed up without freezing and without apparent injury. Certain products under certain conditions may be actually frozen and then thawed out without apparent injury, while, on the other hand, some products are injured by chilling if stored at temperatures well above their actual freezing points.

Evidence seems to show that different individuals of the same variety and strain when grown under different conditions will have somewhat different freezing points, and that there are also some variations in the freezing points of products of the same variety and from the same lot.

In view of these facts the freezing points given in this bulletin should be considered only as danger points at or near which, either above or below, there is a possibility of freezing injury if exposed for a sufficient length of time. These are temperatures at which it is unsafe to hold produce for any length of time, as serious danger of frost injury exists.

Fruits.—The average of the freezing points of 9 varieties of summer apples was found to be 28.44° F., while the average for 14 varieties of fall and winter apples was 28.49° and 28.53° for eastern-grown and western-grown fruit, respectively, showing very little difference between the results for apples of the same varieties.

The freezing points of 7 varieties of cherries averaged 27.81° F.; 7 varieties of American grapes, 28.16°; 2 varieties of European grapes, 24.60°; 6 varieties of oranges, 28.03°; 11 varieties of peaches, 29.41°; 4 varieties of plums, 28.53°; 22 varieties of strawberries, 29.93°; blackberries, 29.15°: white blackberries, 28.40°; Logan blackberries, 29.51°; red raspberries, 30.41°; black raspberries, 28.76°; cranberries 27.16°; green bananas, peel 29.84°, pulp 30.22°; ripe bananas, peel 29.36°, pulp 26°; currants, 30.21°; gooseberries, 28.91°; grapefruit 28.36°; hard-ripe Bartlett pears, 28.46°; soft-ripe Bartlett pears, 27.83°; Japanese pears (unknown variety), 29.39°; Japanese persimmons (Tanenashi), 28.33°.

Fruits freezing above 30° F. are green bananas (pulp), currants, and red raspberries. Those freezing between 29° and 30° are green bananas (peel), ripe bananas (peel), blackberries, Logan blackberries, peaches, Japanese pears, and strawberries. Those freezing between 28° and 29° are apples, blackberries (white), gooseberries, grapes, grapefruit, lemons, oranges, Bartlett pears (hard ripe), Japanese persimmons (Tanenashi), plums, and raspberries (black). Those freezing between 27° and 28° are cherries and Bartlett pears (soft ripe). Cranberries and ripe bananas (pulp) freeze between 26° and 27°. European grapes froze at 24.60°, and Italian chestnuts and Persian or so-called English walnuts froze at 23.80° and 20.00°, respectively.

Vegetables.—The average freezing point of 18 varieties of potatoes was 28.92° F.; for 20 varieties of sweet potatoes, 28.44°; and for 19 varieties of tomatoes (ripe), 30.38°. The freezing points of other vegetables investigated were beans (snap), 29.74°; cabbage, 31.18°; carrots, 29.57°; cauliflower, 30.08°; celery, 29.73°; sweet corn, 28.95°; eggplant, 30.41°; kohl-rabi, 30.02°; lettuce, 31.20°; onions (dry), 30.09°; onion sets, 29.50°; peas (green), 30.03°; turnips, 30.23°.

Two vegetables froze above 31° F., viz, cabbage and lettuce. Those freezing between 30° and 31° were cauliflower, eggplant, kohl-rabi, onions, peas, tomatoes, and turnips. Those freezing between 29° and 30° were beans, carrots, celery and onion sets. Sweet corn, potatoes, and sweet potatoes froze between 28° and 29°.

Cut flowers.—Determinations of the freezing points of the petals and leaves of Easter lilies, peonies, and roses show that Easter lily petals freeze between 27° and 28° F.; rose leaves and peony leaves, between 28° and 29°; peony petals and Easter lily leaves, between 29° and 30°; and rose petals, between 30° and 31°.

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